Evidence for a Recent Increase in Jellyfish in the Bering Sea, with Possible Links to Climate Change

by:

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Introduction

The Bering Sea has undergone major changes in its environment and biota in recent decades. The continental shelf of the Eastern Bering Sea is the second largest in the world and provides rich food resources for large populations of higher-level resident (pollock, flatfish, and shellfish) and transient (salmon, many seabirds and marine mammals) taxa. The shelf is divided into three distinct physical/biological domains (Inner, Middle and Outer Domains) separated by relatively narrow frontal regions around the 50 and 100 m isobaths. Productivity varies greatly on annual and interannual time scales, with the highest levels in the Outer Domain and slope region.

Methods

The Alaska Fisheries Science Center has conducted quantitative bottom trawl surveys of the Eastern Bering Sea shelf annually since 1979. A systematic grid of stations (n = 346) has been occupied from June through August of each year and all tows are standardized as to gear used, towing speed and duration. The entire catch including jellyfish is sorted and weighed. Although these bottom tows are likely to catch jellyfish mainly during deployment and recovery of the trawl, the consistency of the sampling allows construction of an index of their biomass through time.

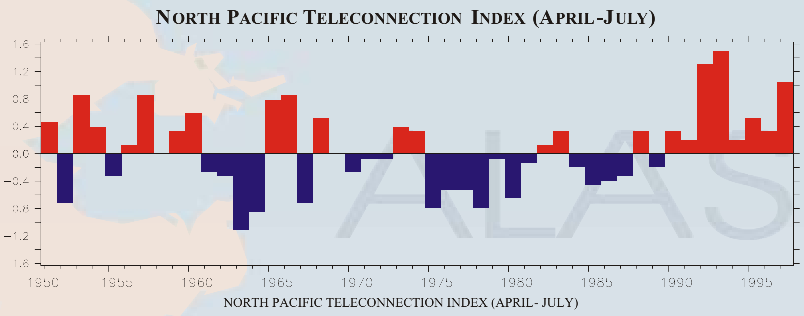

Figure 4: The April-July mean value of the North Pacific (NP) index shown as the first rotated empirical orthogonal function (EOF) of the 700 mb height field. A positive value corresponds to higher heights over the Bering Sea and lower heights for the region south of the Aleutian Islands.

Results

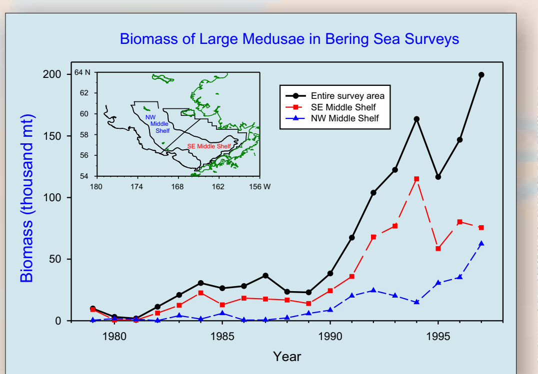

Figure 1: The biomass of medusae caught in the AFSC Bottom Trawl Surveys on the Eastern Bering Sea shelf for 1979 through 1997. The total catch for all six sampling strata is shown by year as well as the catch for only the Southeast and Northwest regions of the Middle Shelf Domain (see inset for locations).

Biomass of medusae was low on the Eastern Bering Sea shelf from 1979 through 1989, but beginning in 1990, there was a dramatic increase in biomass until 1994, with a drop in the cold year of 1995 (Fig. 1). The biomass has increased again the last two years, due mainly to an increase in the Northwest Middle Shelf Region (Fig. 1) with the highest value of the series occurring in 1997. The increase in medusa biomass during the 1980s (1982-89 means by station) was confined mainly to the Middle Shelf Domain between the 50 and 100 m isobath near the Alaska Peninsula (Fig. 2). In the more recent period (1990-1997), the bulk of the medusa biomass remained within the Middle Shelf Domain but had spread to the northwest (Fig. 2). Mean biomass (±SEM) was 0.54 (±0.07) kg ha^{-1} and 2.67(±0.24) kg ha^{-1} for the periods 1982-89 and 1990-97, respectively. The median biomass increased by more than an order of magnitude (0.09 to 1.02 kg ha^{-1}) between these periods. The greatest biomass increase was centered mainly over the Middle Shelf Domain (50-100 m), although the Inner Shelf Domain gained proportionally as much between the two time periods (Fig. 3).

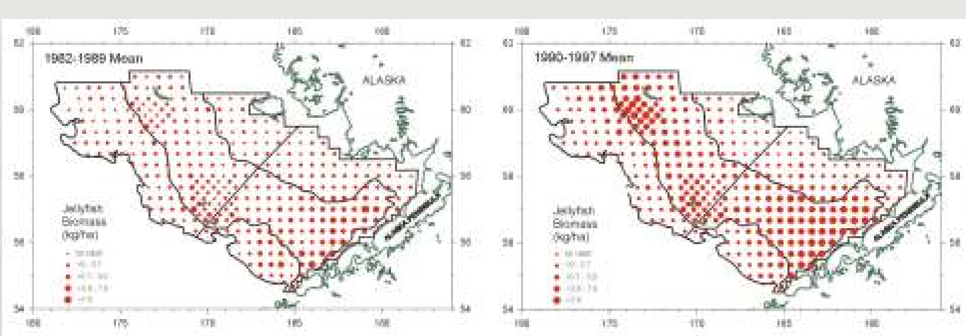

Figure 2: Mean medusa catch per station for each grid station from the periods 1982-1989 (above left) and 1990-1997 (above right). Note the largest increase occurred mainly within the 50 and 100 m isobaths.

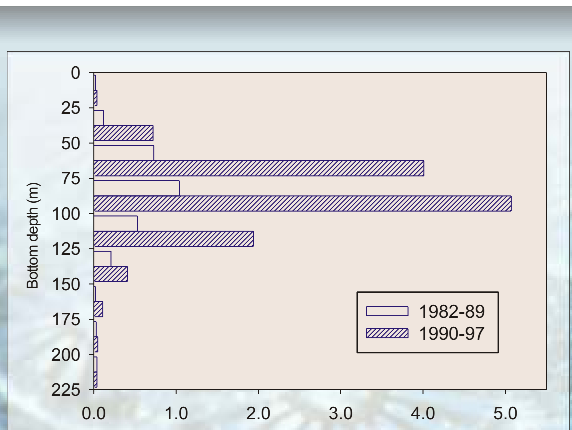

Figure 3: Differences by bottom depth interval between the medusa catch during 1982-1989 (open bars) and 1990-1997 (filled bars).

Figure 7: Underwater video observation of the dominant Bering Sea medusa (*Chrysaora melaster*) with juvenile walleye pollock swimming around the tentacles, taken at a depth of 38 m.

Discussion

Although medusae were not identified to species in the Bering Sea prior to 1994, comparison of the fauna in the late 1990s with that reported for the Bering Sea earlier this century shows no major change in species composition. Increases in biomass are therefore assumed to be intrinsic to the ecosystem rather than due to invasion by a new species, as exemplified by the dramatic increase of ctenophores in the Black Sea earlier this decade which competed with larval and juvenile fishes for food and ultimately led to the demise of several pelagic fisheries. Although medusae in the eastern Bering Sea have shown a substantial biomass increase during this decade, no concomitant precipitous decline in the recruitment of any fish species has been observed in the Bering Sea.

The jellyfish population increase over many years reported here could happen in several different ways. Increased settling success of embryos would yield greater number of benthic polyps, as would conditions on the bottom that allow for greater asexual reproduction of polyps on the bottom, and could also increase the benthic population over time. In the water column, good feeding conditions could either lead to greater spring survival of young medusae, leading to more medusae collected later in the year, or the same number of medusae could have had faster growth rates and reach a larger terminal size in the 1990s, thus increasing overall biomass in late summer.

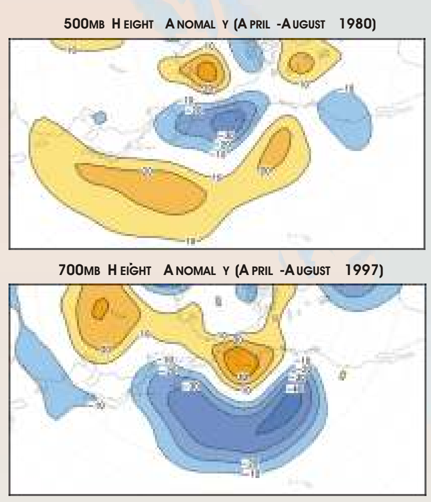

Figure 5: *(bottom)* The 700 mb height pattern anomaly (April-August) during a positive phase of the NP (1997), ***(top)*** The same for a negative phase of the anomaly (1980).

The apparent increased production of medusae may relate to increased sea surface temperatures (SST) caused by changes in the atmospheric general circulation. An important environmental correlate is 700 mb geopotential height over the Bering Sea (Fig. 4). Increased geopotential heights over the Bering Sea imply reduced cloud cover with increased solar radiation to the sea surface. Thus, years with a positive NP value also correspond to years with positive summer SST anomalies (Figs. 5 and 6).

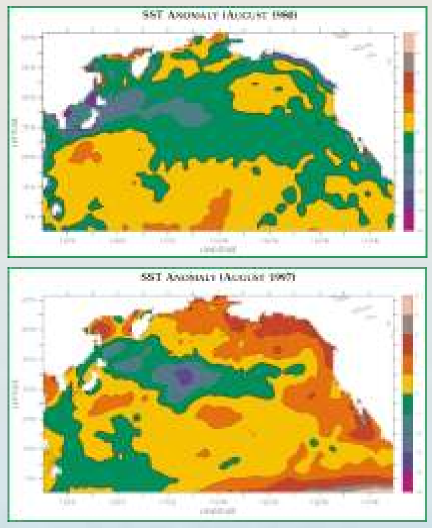

Figure 6: ***(bottom)*** An example of the north Pacific sea surface temperature anomaly in August during a positive phase of the NP (1997), ***(top)*** The same for the negative phase of the anomaly (1980).

The ecological ramifications of this biomass change cannot be ascertained with our present incomplete understanding of the Bering Sea ecosystem. Gelatinous zooplankton may affect fisheries resources in ways that are both beneficial and deleterious. Potential negative impacts include competition for limited resources with, or direct predation on, early life stages of fishes. However, the juvenile stages of some fish species may utilize large medusae as shelter sites from intensive predation in the pelagic realm (Fig. 7). Although jellyfish are known to be fed upon by some seabirds in the Bering Sea, few other predators on these large medusae are known and this biomass may represent a vast unavailable reservoir of carbon in this system. However, these medusae may contribute a substantial carbon flux to the benthos in the winter when they die and sink to the bottom.

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